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Rack Tailstock Design

By Martin Cleeve

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Making the most of your lathe

The skew-rack tailstock mechanism

In this article—first of two — MARTIN CLEEVE tells how all the skew-rack components may be machined in the lathe

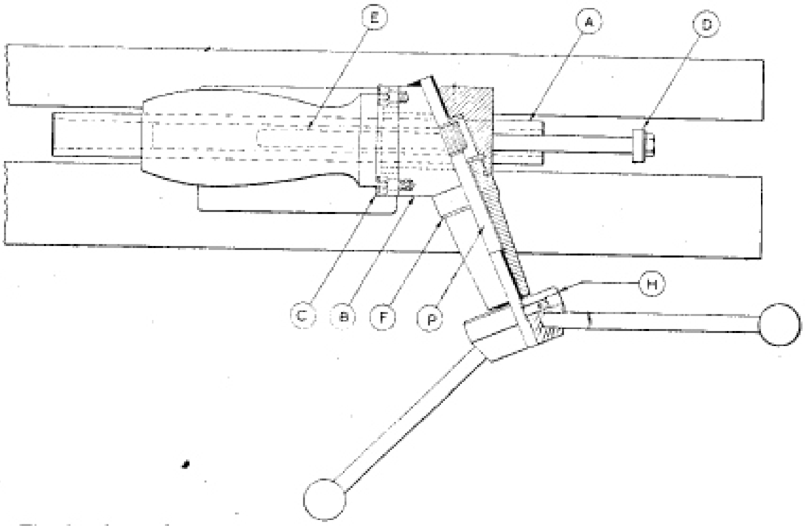


Fig. 1: General arrangement of the skew-rack feed tailstock mechanism

IT IS WELL KNOWN that the tailstock of a lathe has many functions apart from that of giving support to work held between centres, but its usefulness is greatly enhanced when the barrel is provided with rapid and powerful means of movement such as that afforded by the rack and pinion mechanism.

Perhaps it should be mentioned that this rack tailstock mechanism should not be regarded as an attachment but as a permanent alteration; some engineers appear to be under the impression that it must be removed and replaced by the screw barrel for working between centres. Such a course is quite unnecessary. I have used the rack ,mechanism for all purposes for many years without the slightest fear of its slipping when once locked in the normal manner.

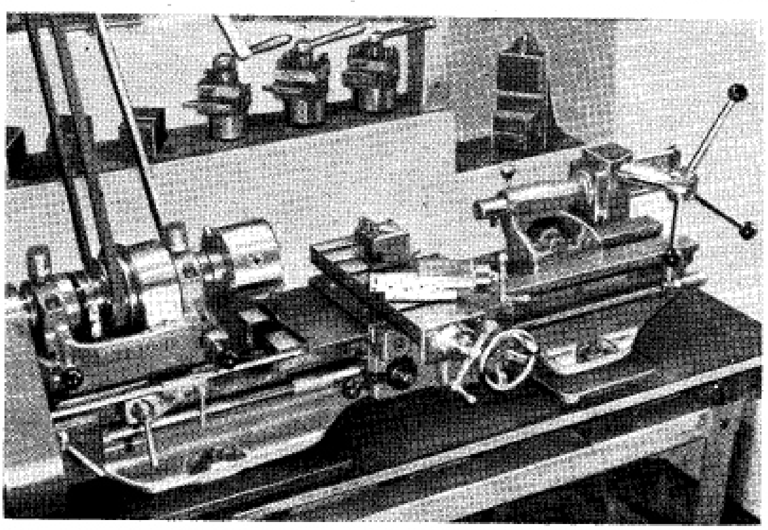
This skewed arrangement is the design resulting from experience gained with a right-angular type fitted to a Myford ML4 lathe some years ago, and which was illustrated in a fairly recent article.

Skewing is a worthwhile refinement enabling the lever operating handles to be situated in a convenient and more orthodox position, while at the same time ensuring that they are, under all circumstances, clear of the cross-slide and topslide and the saddle traverse handwheel.

A further useful feature inherent in the design is that the barrel meets a dead stop in both the full forward and retracted positions, and this, together with the built-in tool ejector, changes the tailstock into an efficient and versatile part of the lathe which is a pleasure to use and with which tools may be changed as quickly as with a six station turret but without the usual obstruction caused by the five unused tools when such a tailstock turret is used on a small lathe.

In some of the operational pictures

The lathe with the rack tailstock mechanism attached



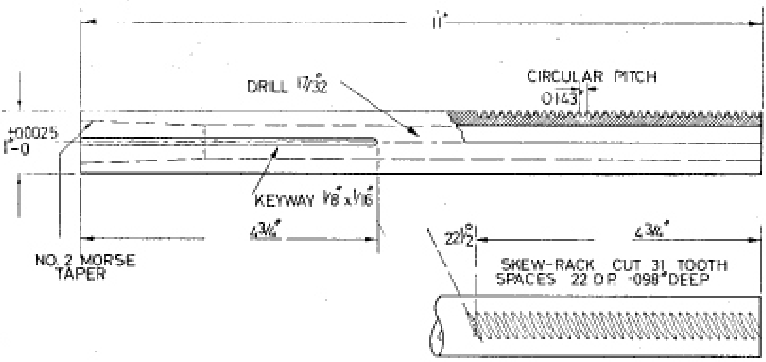
illustrating this article, it may be noticed that the lathe is already fitted with the type of tailstock being described as under construction. This came about because when the original was made a camera was not available and in order to obtain a set of pictures a second unit was built.

The general arrangement drawing (Fig. 1) and the various photographs will give a fair idea of the layout and of the component parts which make up the unit.

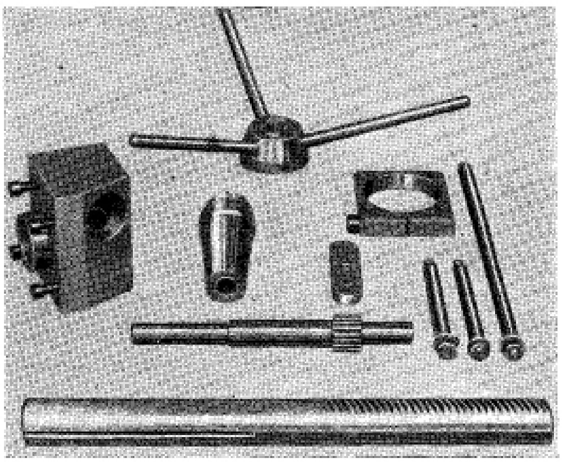
The constructional notes which follow touch only upon the salient points but as there are a number of somewhat unusual operations and set-ups it is hoped that they will be of general use in indicating methods of attacking other jobs of a similar nature and that those not actually contemplating the conversion will, nevertheless, still find something to interest them.

The drawing (Fig. 2) gives details of the barrel. For this Stubbs 1 in. dia. silver steel was used without further treatment to the outer surface other than a light longitudinal polishing. Stubbs silver steel is excellent for those cases where the duty is of a sliding nature; also it is somewhat harder and has a higher tensile strength than mild steel.

In order to maintain concentricity the set-up shown in the photograph (Fig. 3) was adopted. Here the work is held at one end in the three-jaw chuck while support is given to the other end by means of a bushing type fixed steady.

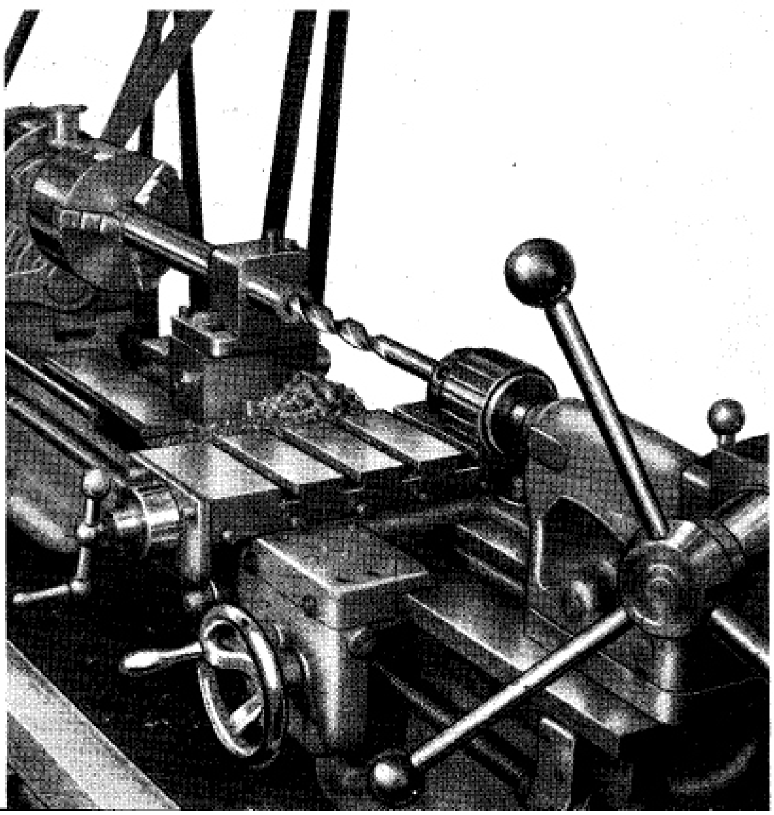


Above, Fig. 2: Details of the barrel



Right: Components of the mechanism

Below, Fig. 3: Boring out the barrel



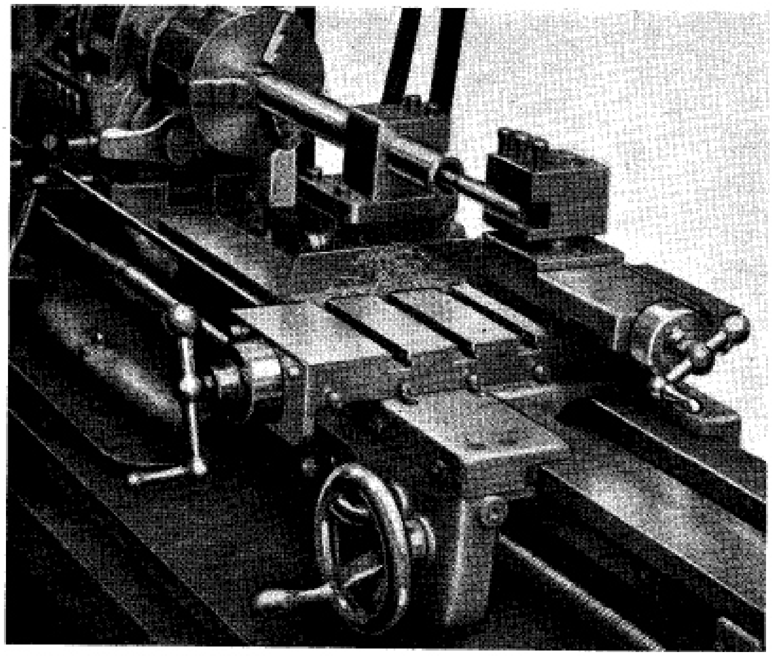
The three-jaw chuck is without a register to the backplate so that the body may be adjusted until the work is running truly; the four-jaw independent chuck could be used of course, but for such work as this I find it quicker to offset the chuck body to suit the job.

The barrel was drilled from each end; an initial $\frac{5}{16}$ in. hole being made as deeply as possible to facilitate the use of the final 17/32 in. drill.

Before setting to cut the Morse taper it was found necessary to parallel bore the drilled hole to a diameter of just under $\frac{9}{16}$ in. to a depth of $2\frac{11}{16}$ in. to ensure that the inner end of the final taper bore should be large enough to accommodate the small ends of the taper adaptors to be used. During the actual taper boring operation it is possible to be misled in this respect and to gain the impression that the taper setting of the topslide is too acute.

The set-up for boring the Morse taper is shown in Fig. 4. The topslide was set at the required angle by

The skew-rack tailstock mechanism . . .



reference to an external taper tang held in the chuck and as a double check an external taper was cut on an odd piece of stock, the tool being held upside-down so that the boring tool could be substituted without altering the topslide angular setting.

Centre height is important for this kind of work and those boring a taper for the first time should make frequent tests with a chuck arbor or other taper plug marked with chalk. Note that only a small amount of metal has to be removed to complete the bore.

I now have the luxury of a No. 2 Morse taper reamer to finish the bore, but I used to manage quite well by wrapping a piece of fine carborundum cloth around a taper tang and gently working this into the bore while rotating the work by hand.

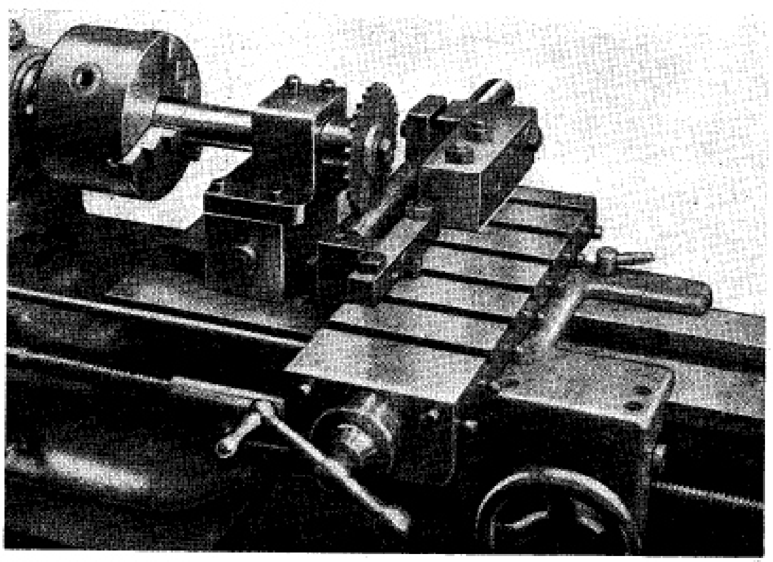
An end mill could have been used for cutting the keyway, but end mills do not always leave a nice flat surface on the sides of the slot and, in this case, such a small cutter would be liable to break. For the most certain results it was, therefore, felt advisable to use a radial cutter, (Fig. 5).

In my case, not wishing to go to the expense of a cutter of smaller diameter, I had a little extra bother in devising a jig for use with the 3 in. by $\frac{1}{8}$ in. cutter used. Before cutting the actual slot, the set-up was tested upon a short piece of 1 in. dia. mild steel to check the depth.

In order that the barrel should have the advantage of a definite forward dead stop, the inner portion of the keyway which, with the radial cutter gradually " washes out," was cleaned out to full depth with a $\frac{1}{8}$ in. dia. end mill.

Above, Fig. 4: Boring the No. 2 Morse taper in the barrel

Below, Fig. 5: Cutting the keyway slot in the barrel



Cutting the rack

Once the pitch had been decided upon and the work-holding block made, cutting the rack was found to be a very pleasant occupation—especially for one who does not have to make a living at it ! The photograph (Fig. 6) shows this operation and the drawing, Fig. 7, gives details of the holding block.

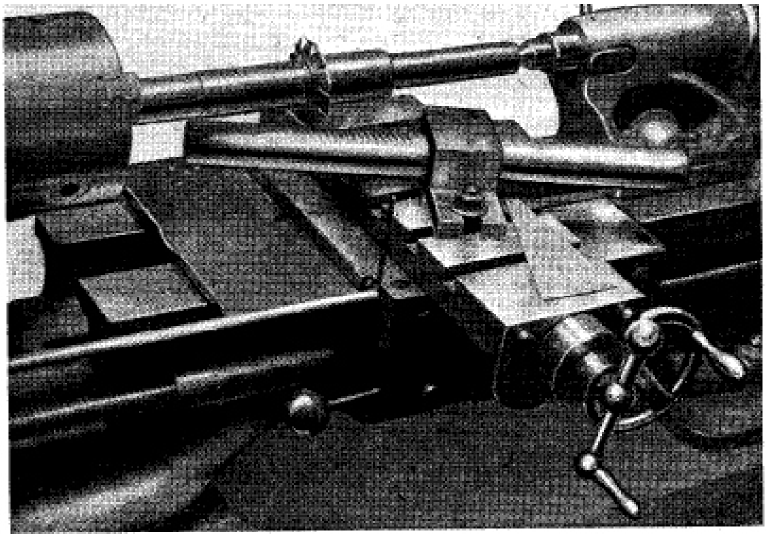
The distance between the centre line of the bore and the underside of the work holding block—shown as dimension X on Fig. 7—is such that the barrel is supported at the correct height to give the required tooth depth while allowing for the interposition of a piece of card of ten thou. thickness between the cross-slide and the block.

This fixture was, of course, tested; a few tooth spaces being cut upon a short length of 1 in. dia. stock. The depth of space was checked by squeezing a piece of soft solder into one of them and measuring the moulded piece with the micrometer.

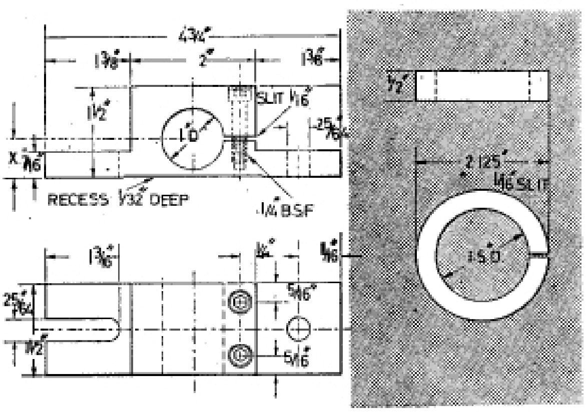
To be certain that all the tooth spaces are of the same depth it is important that the block shall hold the barrel parallel to the lathe bed within close limits. To make sure of this, when the block was nearly completed it was mounted, with the base facing outwards, upon a 6 in. length of 1 in. dia. stock which was transversely held between two angle pieces fixed to the lathe faceplate. After setting the 1 in. dia. bar exactly parallel to the faceplate a fine facing cut was taken over the base of the block.

Subsequent checking with a dial indicator showed that the extreme outer end of the barrel was tipped up by only two thou. when mounted as shown in the photograph—a not unsatisfactory result !

The triangular-shaped piece of sheet zinc which may be seen resting upon the cross-slide (Fig. 6) is the 22½ deg. gauge used to set the work holding block. Such angular gauges are easily made from sheet zinc. After carefully marking out from a school protractor the scribed lines may be deepened by repeated scribing whereupon the metal readily breaks off exactly along the line so scribed.



Above, Fig. 6: Cutting the skew rack



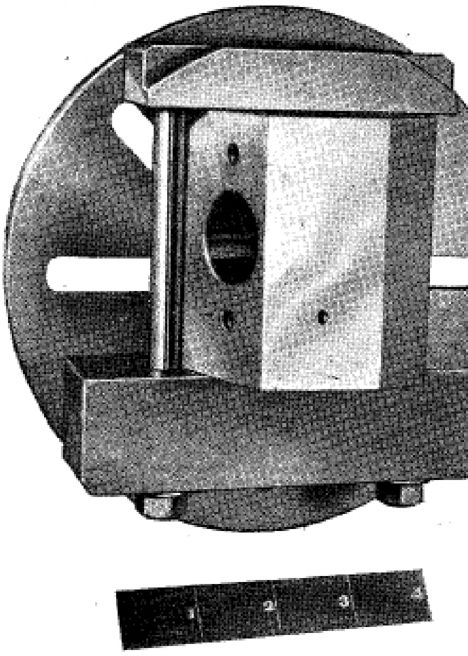
Left, Fig. 7: Barrel holding block for rack cutting, and the clamp locating ring

Indexing the tooth spaces was a simple matter. The circular pitch (the distance between the centre of one tooth and the centre of the next) in No. 22 diametral pitch is 0.143 in. The diameter of a No. 27 twist drill shank is 0.144 in. so this was used in conjunction with the adjustable saddle dead stop bar where it may be seen left in position for the purpose of illustration.

The barrel is adjusted in the holder with the keyway facing the tailstock and 5¼ in. projecting on the other side for the rack teeth, the cutting of which was commenced close to the block.

● *To be concluded*

Making the most of your lathe



The skew-rack tailstock mechanism

Part 2

MARTIN CLEEVE concludes his constructional notes and discusses the practical aspects of the mechanism

THE PREVIOUS ARTICLE covered the chief points connected with machining the barrel and cutting the rack. In this concluding article the remaining components are detailed, together with brief machining sequence notes where necessary.

The main block was made from a 3½ in. length of 2½ in. square section bright mild steel and was a fairly straightforward machining operation. The drawing, Fig. 8, gives the dimensions.

As it was not possible to hold it securely in the skewed position in a four-jaw chuck for facing and skew boring, it was mounted on the faceplate in the manner shown in the photograph, Fig. 9, where it is shown held between two pieces of square stock, these being drilled and tapped at the rear for fixing to the faceplate.

A satisfactory sequence of operations was found to be to:

1. Face each end to length (four-jaw chuck).
2. Drill and bore through 1⅛ in., taking the bore centre line from the top of the block as a datum.
3. Mount on faceplate and face off angle. For this facing operation the block may be symetrically

Top, Fig. 9: Mounting the main block to the faceplate for facing off and skew boring

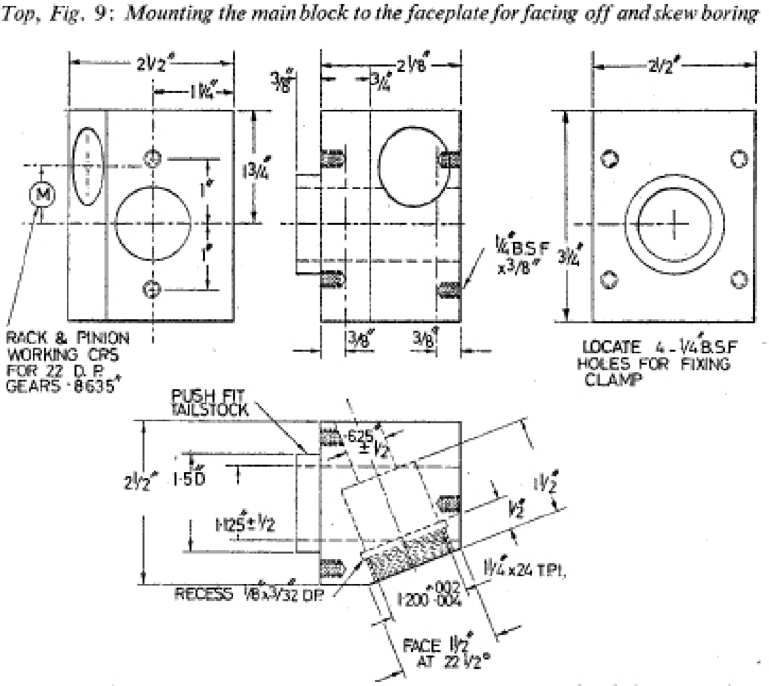


Fig. 8: Dimensions and details of the main block

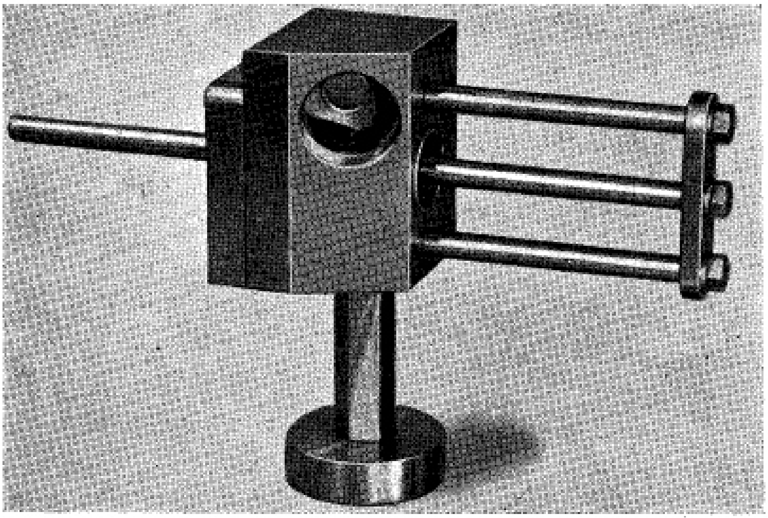


Fig. 10: View of the skew bore and the ejector assembly

mounted between clamp bars, or pieces, of equal weight and cross section, thus giving balance for high speed facing.

4. Mount upon a 1⅛ in. mandrel between centres, or chuck and centre, and machine the ⅜ in. length by 1⅛ in. dia. locating boss or register.
5. For marking the pinion shaft centre line use the same datum line or surface as that used for marking the barrel centre line, i.e. the "top" of the block. The required centre distance for this particular case (22 d.p. gearing) is 0.8635 in. The barrel centre line from the top was 1.7500 in., therefore the pinion shaft centre line may be marked 1.7500 minus 0.8635 in., this being 0.8865 in. from the top.

To obtain a measurement of this nature the block may be stood upside-down upon a flat surface, the line being scribed over a piece of ⅞ in. square bright steel standing upon a piece of 0.0115 in. cardboard.

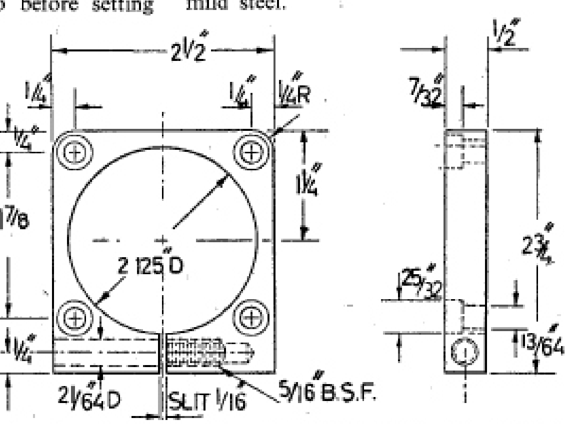
6. The block is bushed in the 1⅛ in. bore, at the right-hand end, with a "Compo" oil retaining bush having a length of ⅞ in. and a bore of 1 in. to give further support to the barrel at that point. While machining the skew bore part of this bush is turned away, so before setting on the faceplate for skew boring this bush must be pressed home.
7. Having marked, spot and centre drilled the pinion-shaft centre line, mount the block as shown in the photograph, Fig. 9, interposing paper or card between the gripping surfaces as an insurance against slipping, and, with the clamps partially tight, use the test indicator to set for the concentric running of the centre hole and to check the true running of the angled off face.
8. Drill, bore and thread to suit the extension piece, Fig. 14.

Some caution is needed if the initial drilling is carried out with a drill much larger than ½ in. dia. as it will break through into the barrel bore, upon which there will be a marked tendency for it to snatch and to be thrown off the centre line.

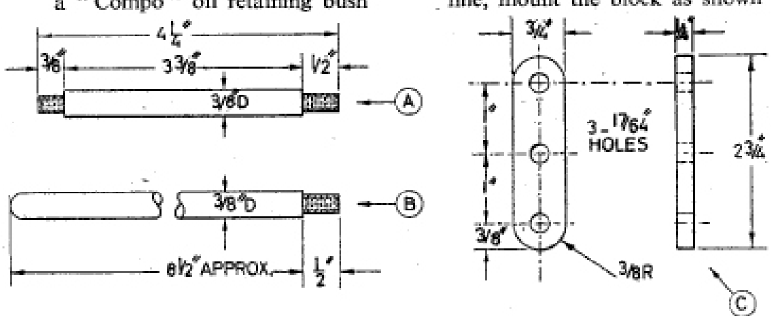
Skew bore details

The photograph, Fig. 10, shows the appearance of the skew bore and the ejector assembly, details of the latter being given in the drawing, Fig. 11.

The fixing clamp method of locking the mechanism to the tailstock body has been found highly satisfactory and results in a practically solid union of the two members. Details of the clamp are given in the drawing, Fig. 12. It is made from a 2¾ in. length of 2½ in. by ½ in. bright mild steel.



Right, Fig. 12: Dimensions and details of the fixing clamp



Bottom, Fig. 11: The ejector components. (a) support rods; (b) ejector rod; and (c) the end piece

The photograph, Fig. 13, shows how this clamp is fixed to the main block. This photograph also shows, at the left-hand side, the split machined ring which was used to locate the clamp piece while drilling the clamp fixing holes in the main block. The split ring is an exact copy of the machined end of the tailstock casting.

The bore of the extension piece, Fig. 14, is made 0.625 in. to suit a ⅝ in. o.d. "Compo" bush at the right-hand end, and to facilitate finish machining the threaded portion etc., while mounted on a ⅝ in. mandrel.

The pinion shaft may be made from a 6½ in. length of silver or "axle" steel. The 0.625 in. dia., Fig. 15, facilitates holding in a ⅝ in. bore

The skew-rack tailstock mechanism—2 . . .

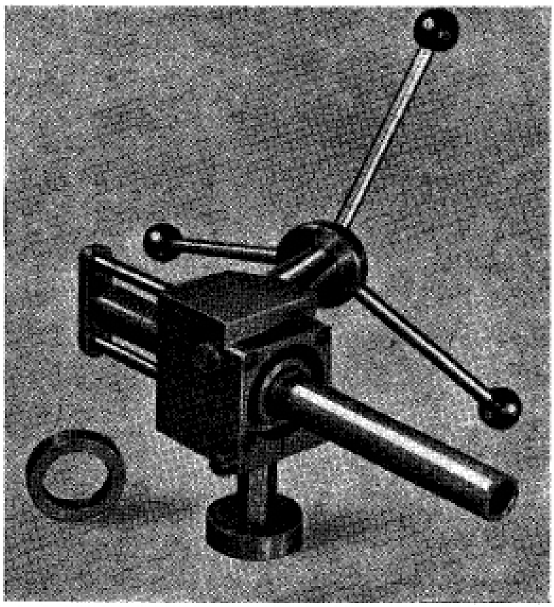


Fig. 13: Rear ,iew of the mechanism. The split ring is for locating the clamp fixing holes

" jig block " during tooth cutting, as shown in the photograph, Fig. 16. Upon completion of the tooth cutting operation, this ⅜ in. step is, of course, reduced by 0.010 in. to clear the bore in the extension piece, Fig. 14.

Details of the three lever " handwheel " will be found in Fig. 17. This forms quite a pleasant piece of machining from mild steel stock and needs no further comment, save for the fact that experience has shown that the locking grub screw, which is of the hexagon socket head, high-tensile type, tends to work loose with the shock load brought about by the use of the ejector arrangement; an eventuality which indicates that a keyway and key would make a superior job.

Shank seizure

The ejector arrangement is used by smartly retracting the barrel by means of the lever handwheel, the fixed central rod, Fig. 10, knocking out the lathe centre or other tapered tool.

Some readers have expressed concern over the possibility of a shank becoming firmly fixed in the taper bore. I have found that while this does occasionally happen it is a very rare occurrence, and experience has shown that a tool most likely to jam will be one which has been left in position over-night; in any case, if smart retraction fails to free a tool the barrel may be held in the fully retracted position while the ejector rod assembly is given a tap or two with a 2 oz. hammer.

If the seizure is so severe that this will not free it, loosening the ejector rod nut followed by tapping at full retraction will never fail. In this latter case, a piece of cloth should be placed over the lathe bed to protect both the bed and the ejected member which, under these circumstances, sometimes shoots out with violence.

It should be noted that while this trouble is experienced it is, as stated, rare, and the advantage of the ejecto so far outweighs the potential dis advantage that, for myself at any rate, its abandonment in favour of the old " bashing out bar "—which was often lost—would be absolutely unthinkable.

It would take a more able pen than mine to describe the pleasure to be derived from the use of the tailstock, so I shall have to confine my concluding remarks to briefly noting some of the advantages.

The ready and rapid retraction of the barrel facilitates the insertion or removal of drilled work from the headstock chuck. The free sliding action of the barrel enables threading taps to be as readily used as dies. Reamers are easily used, as frequent retraction for chip clearance is no ‘rouble.

Advantages of the unit

The action is powerful and sensitive. The slightest change in feed pressure or cutting conditions is transmitted to the hands, therefore very small drills may be used as readily as those

Fig. 15: Details of the pinion shaft

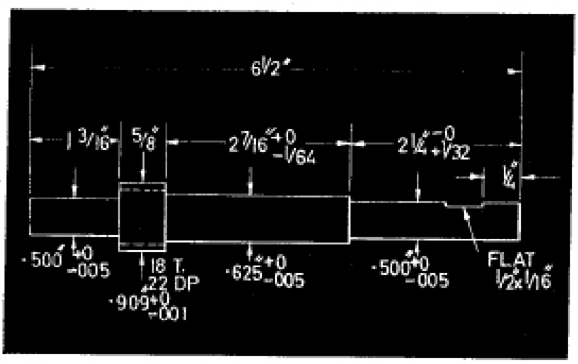
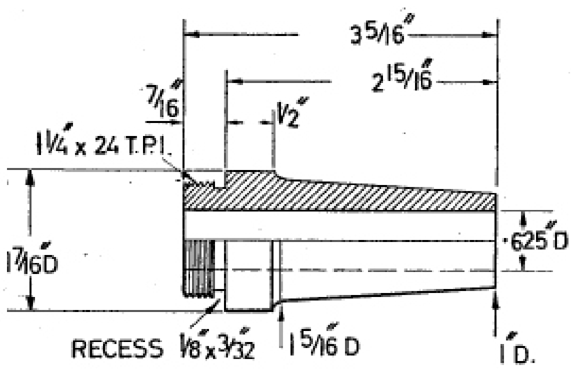
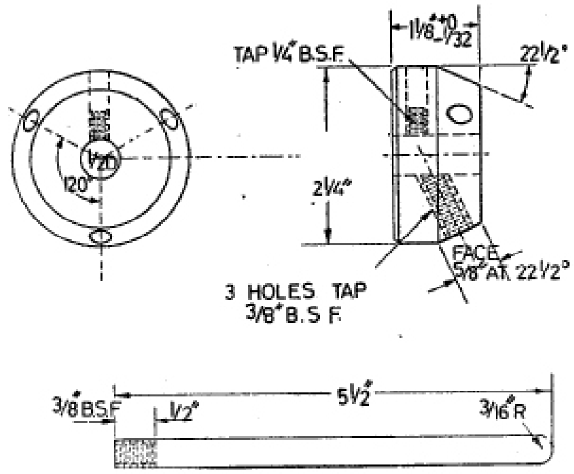


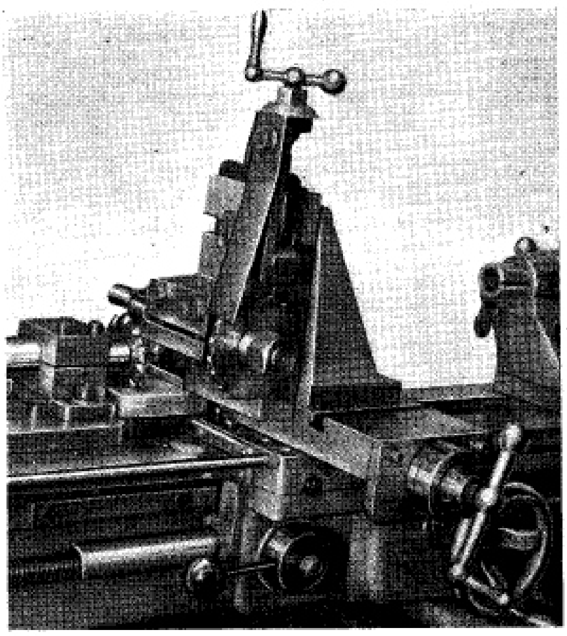
Fig. 14: Diagram of the extension piece





Above, *Fig.* 16: *Details of the handwheel*

Right, *Fig.* 17: *Cutting the pinion*



up to 1 in. dia., the latter, of course, being used to open out previously drilled holes.

Using the tailstock to push a keyway cutting tool held in the normal lathe toolpost provides a powerful in line push to the tool shank, making light work of keyway cutting in all metals including mild steel. In this case I refer to keyway cutting in the bores of pulleys, gears, etc., held in the chuck.

Such work as this is sometimes carried out by feeding the tool with the leadscrew or saddle traverse handwheel. It does not seem to be generally appreciated that this throws a tremendous strain on these components—a strain far exceeding that for which these comparatively small machines were built. ■